Geophysical Research Abstracts
Vol. 18, EGU2016-7414, 2016
EGU General Assembly 2016

Sand fairway mapping as a tool for tectonic restoration in orogenic belts

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The interplay between regional subsidence mechanisms and local deformation associated with individual fold-thrust structures is commonly investigated in neotectonic subaerial systems using tectonic geomorphology. Taking these approaches back into the early evolution of mountain belts is difficult as much of the key evidence is lost through erosion. The challenge is to develop appropriate tools for investigating these early stages of orogenesis. However, many such systems developed under water. In these settings the connections between regional and local tectonics are manifest in complex bathymetry. Turbidity currents flowing between and across these structures will interact with their substrate and thus their deposits, tied to stratigraphic ages, can chart tectonic evolution. Understanding the depositional processes of the turbidity currents provides substantial further insight on confining seabed geometry and thus can establish significant control on the evolution of bathymetric gradients and continuity through basins. However, reading these records commonly demands working in structurally deformed terrains that hitherto have discouraged sedimentological study. This is now changing. Sand fairway mapping provides a key approach. Fairway maps chart connectivity between basins and hence their relative elevation through time. Larger-scale tectonic reconstructions may be tested by linking fairway maps to sand composition and other provenance data. More detailed turbidite sedimentology provides substantial further insight. In confined turbidite systems, it is the coarser sand component that accumulates in the deeper basin with fines fractionated onto the flanks. Flow bypass, evidenced by abrupt breaks in grading within individual event beds, can be used to predict sand fraction distribution down fairways. Integrating sedimentology into fairway maps can chart syntectonic slope evolution and thus provide high resolution tools equivalent to those in subaerial tectonic geomorphology. The stratigraphic records are preserved in many parts of the Alpine-Mediterranean region. Examples are drawn from the Eo-Oligocene of the western Alps and the early Miocene of the Maghreb-Apennine system to illustrate how turbidite sedimentology, linked to studies of basin structure, can inform understanding of tectonic processes on regional and local scales. In both examples, sediment was delivered across deforming basin arrays containing contractional structures, sourced from beyond the immediate orogenic segments. The depositional systems show that multiple structures were active in parallel, rather than develop in any particular sequence. Both systems show that significant deformation occurs, emerging to the syn-orogenic surface ahead of the main orogenic wedge. The cycling of uplift and subsidence of “massifs” can be significantly more complex that the histories resolved from thermochronological data alone.